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Catchment Analysis of Selected Streams In The Payette National Forest

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CATCHMENT ANALYSIS OF SELECTED STREAMS IN THE PAYETTE NATIONAL FOREST

Prepared for USDA Intermountain Forest
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By

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SUMMARY

The present study investigated the effects of various land-use practices and intensities on selected streams in the Boulder Creek, Little Weiser River, and Hazard Creek catchments within the Payette National Forest. Multivariate analyses was used to determine variable(s) (biotic and abiotic) which displayed differences among the three catchments. Reduced alkalinity and specific conductance distinguished sites in the Hazard Creek catchment from the other streams examined. Further, the Hazard Creek sites displayed reduced macroinvertebrate taxa richness and diversity. Sites in the Boulder Creek and Little Weiser River catchments were found to be similar in terms of habitat characteristics, although differing in macroinvertebrate community measures. Squirrel Creek, within the Boulder Creek catchment, displayed impaired benthic habitat, possibly as a result of livestock grazing. However, the biotic health of Squirrel Creek did not appear to be decreased as a result of the impaired habitat. A significant relationship was found between substrate embeddedness and benthic organic matter, particularly for sites of the Little Weiser River catchment. This suggests that land-use practices may be contributing organic sediment to receiving streams.

Table 1. Location of the study streams.

Stream	Date Sampled	Elevation (m)	Section	Range	Township	Coordinates
LITTLE WEISER RIVER CATCHMENT						
Upper Little Weiser	09/02/93	1500	17	R2E	T14N	44 33'N, 116 15'W
Lower Little Weiser	09/02/93	1220	29	R2E	T14N	44 31'N, 116 15'W
Sheep	09/02/93	1830	27	R2E	T14N	44 31'N, 116 12'W
Anderson	09/03/93	1520	15	R2E	T14N	44 32'N, 116 12'W
BOULDER CREEK CATCHMENT						
Upper Boulder	08/25/93	1800	8	R1W	T20N	45 05'N, 116 29'W
Lower Boulder (blowdown)	08/25/93	1560	34	R1W	T21N	45 07'N, 116 26'W
Boulder - 1992	06/25/92	1500	24	R1W	T21N	45 08'N, 116 23'W
Yellowjacket	06/26/92	1700	22	R1W	T21N	45 08'N, 116 27'W
Pony	06/30/92	1660	6	R1E	T21N	45 11'N, 116 22'W
Squirrel	08/26/93	1650	31	R1E	T22N	45 12'N, 116 22'W
HAZARD CREEK CATCHMENT						
Brown	08/23/93	1590	32	R2E	T21N	45 07'N, 116 14'W
Hazard	08/25/93	1130	18	R2E	T21N	45 12'N, 116 16'W
Hard	08/24/93	1130	31	R2E	T22N	45 09'N, 116 16'W

Table 2. Summary of variables, sampling methods, and analytical procedures used in the study.

Variable	Type*	Sampling Method	Analytical Method	Reference
A. Physical				
Temperature	P	Field measurement	Digital thermometer	
Substratum Size	R	Measure x-axis of 100 randomly selected substrata	Calculate mean substratum size	Leopold 1970
Substratum Embeddedness	R	Visual estimation on 100 randomly selected substrata	Calculate mean substratum embededdness	Platts et al. 1983
Stream Width	T	Measure bank-full width using a nylon meter tape	Calculate mean stream width	Buchanan and Somers 1969
Stream Depth	R	Measure water depth at the 100 randomly choosen substrata	Calculate mean water depth	
Discharge	T	Velocity/depth profile Velocity measured with a small C-1 Ott meter	Q=WxDxV; where Q=discharge, W=width, D=depth, and V=vel	Bovee and Milhous 1978
B. Chemical				
Conductivity	P	Field measurement	Temperature compensated meter (ORION model 126)	APHA 1989

* P=point measure; T=transect across stream; R=random throughout a defined reach.

habitat condition. These habitat measures were then used in multivariate analyses.

Methods used for sampling macroinvertebrates are described in Platts et al. (1983). Procedures for summarizing data collected also are described in Table 2. Macroinvertebrates were examined in terms of density, biomass, species richness, and top ten most abundant taxa. Nine macroinvertebrate metrics known to be important in Idaho streams (Robinson and Minshall 1992) also were calculated. These indices of importance included: Shannon's Diversity (H'), Simpson's Index, % Filterers, % Scrapers, % Shredders, % Dominant, Hilsenhoff Biotic Index (HBI)(Hilsenhoff 1988), Ephemeroptera/Plecoptera/Trichoptera (EPT) Richness, and the % EPT.

Multivariate statistical analyses were used to examine differences among catchments. Principal components analysis (PCA) and multiple discriminant analysis (MDA) were utilized. The multivariate analyses were conducted on habitat measures, macroinvertebrate community measures, and the relative abundance of the ten most abundant macroinvertebrate taxa from each site. To increase normality of the data, standard transformations were conducted prior to the analyses (Zar 1984).

RESULTS

Physical and Chemical Measures

Stream order, discharge, and slope varied considerably among sites (Table 3). Little variation in Ph was measured among catchments or among sites in each catchment. Total hardness values varied greatly among sites, ranging from a minimum value of 12 mg $CaCO_3$/L in Hard and Pony Creeks to a maximum of 40 mg $CaCO_3$/L at the lower Boulder Creek site. Specific conductance and total alkalinity, however, were noticeably lower in streams

of the Hazard Creek catchment (Table 3). Although no geologic information was available, these data suggest a possible difference in the geology of the underlying bedrock of the Hazard Creek catchment.

Stream Habitat Characteristics

Mean near-bed water velocities were not substantially different among sites, although the coefficients of variation (cv) were often greater than 1 suggesting a large amount of spatial variability within a site (Table 4). Yellowjacket Creek displayed a considerably lower mean substrate size compared to all other sites. Mean substrate size in Hazard Creek was approximately twice as great as in either Brown or Hard Creeks. Measurements of water depth and stream width showed no clear patterns and tended simply to reflect stream size.

Cross-sectional profiles for the study streams are presented in Figures 2-5. One transect on the Upper Little Weiser River displayed an exceptionally wide cross-sectional profile and appeared to be an outlier (Figure 2). Profiles of the other streams in the Little Weiser River catchment did not indicate channel degradation or alteration. Squirrel Creek, while being quite similar to Pony and Yellowjacket Creeks in terms of size and slope, displayed substantially different cross-sectional profiles (Figure 4). Livestock grazing was evident adjacent to Squirrel Creek suggesting that past livestock use within the catchment may have resulted in the apparent widening of the stream.

In general, streams of the Boulder Creek catchment displayed the highest levels of periphyton chlorophyll-*a* and ash-free dry mass (Figure 6). Within the Boulder Creek catchment, Squirrel Creek exhibited the greatest mean chlorophyll-*a* value. Again, this may have been an effect of livestock grazing causing an opening of the riparian canopy. A similar pattern was observed

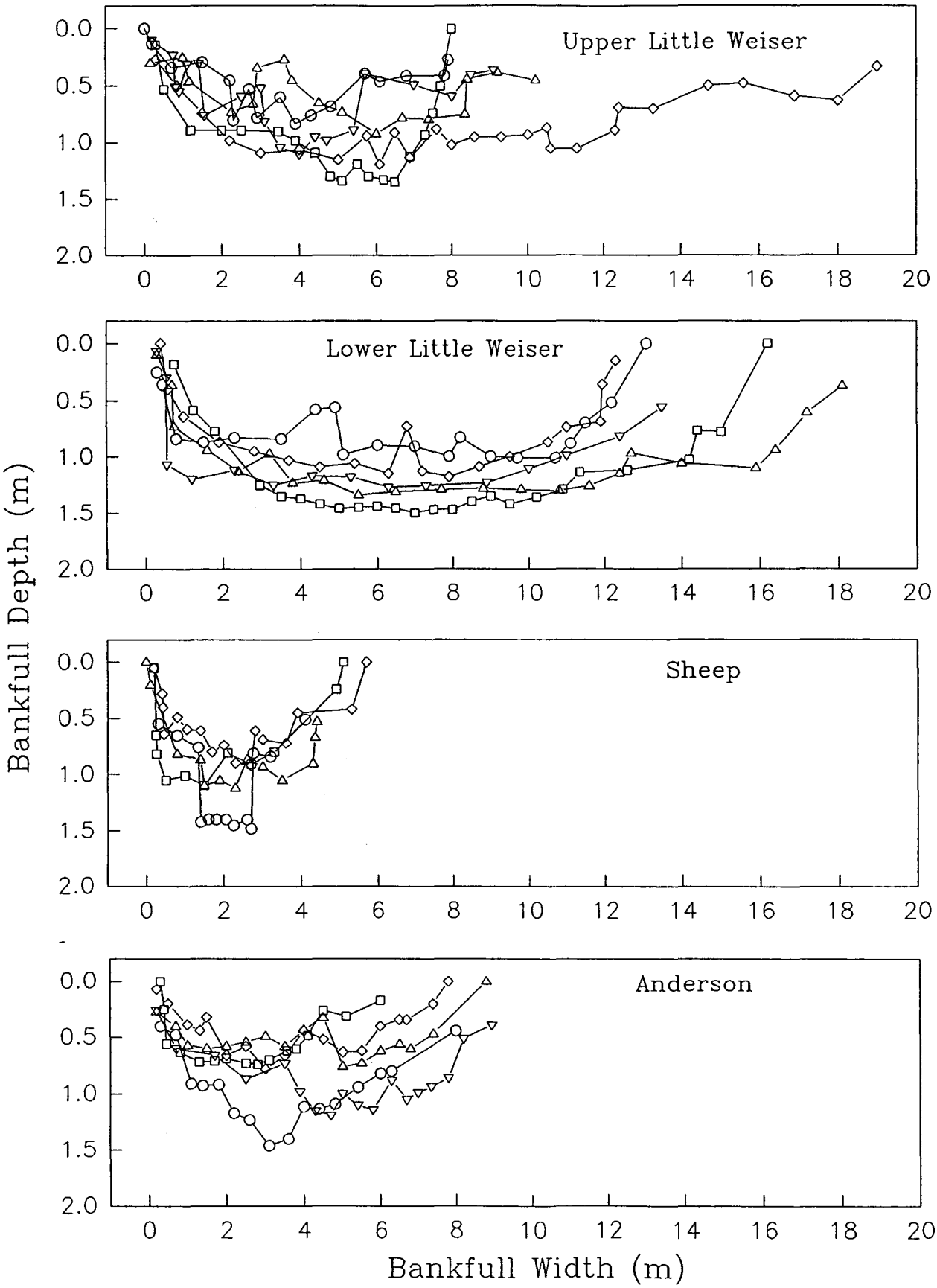

Figure 2. Cross-sectional profiles for study streams in the Little Weiser River catchment.

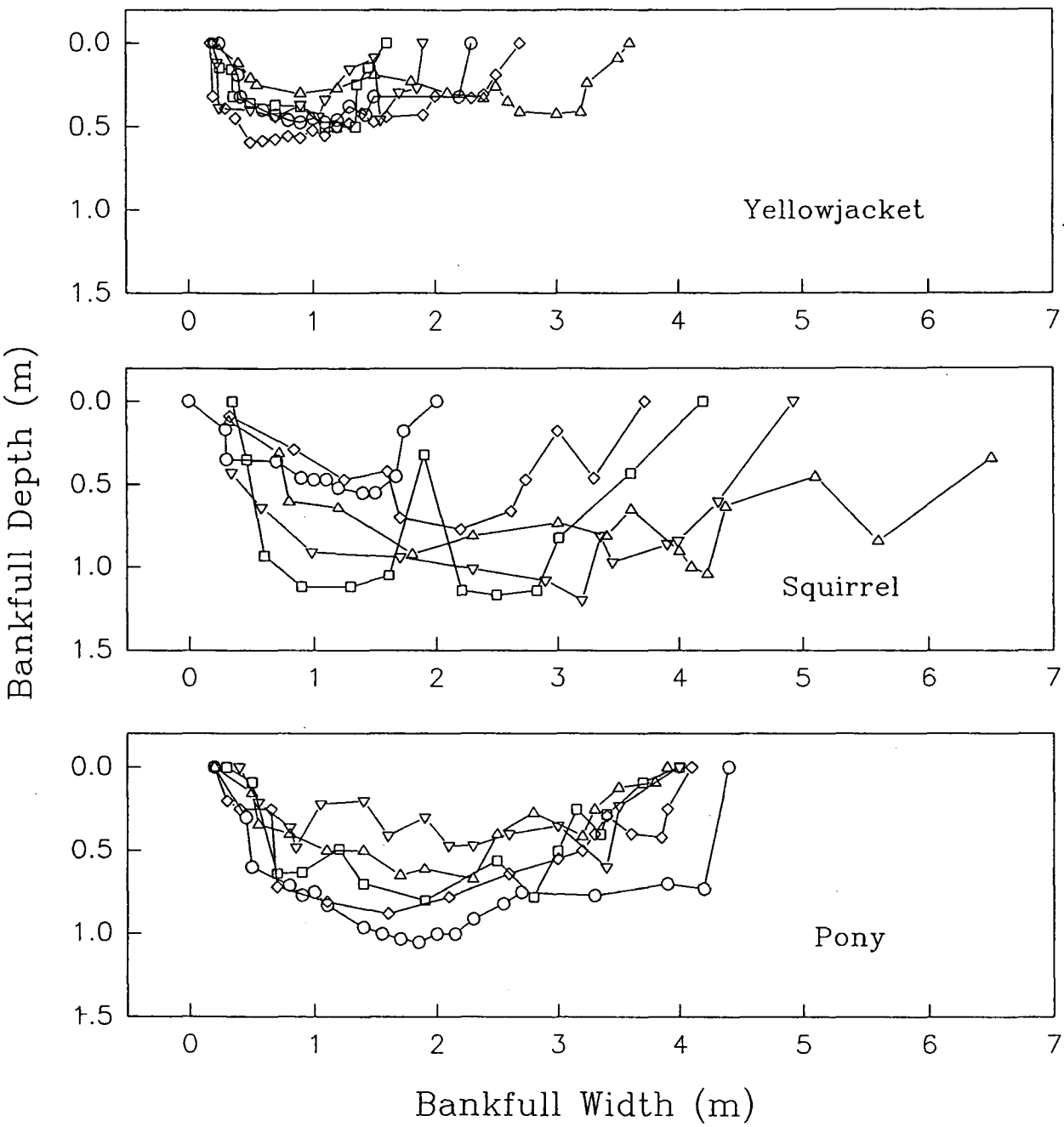

Figure 4. Cross-sectional profiles for study streams in the Boulder Creek catchment.

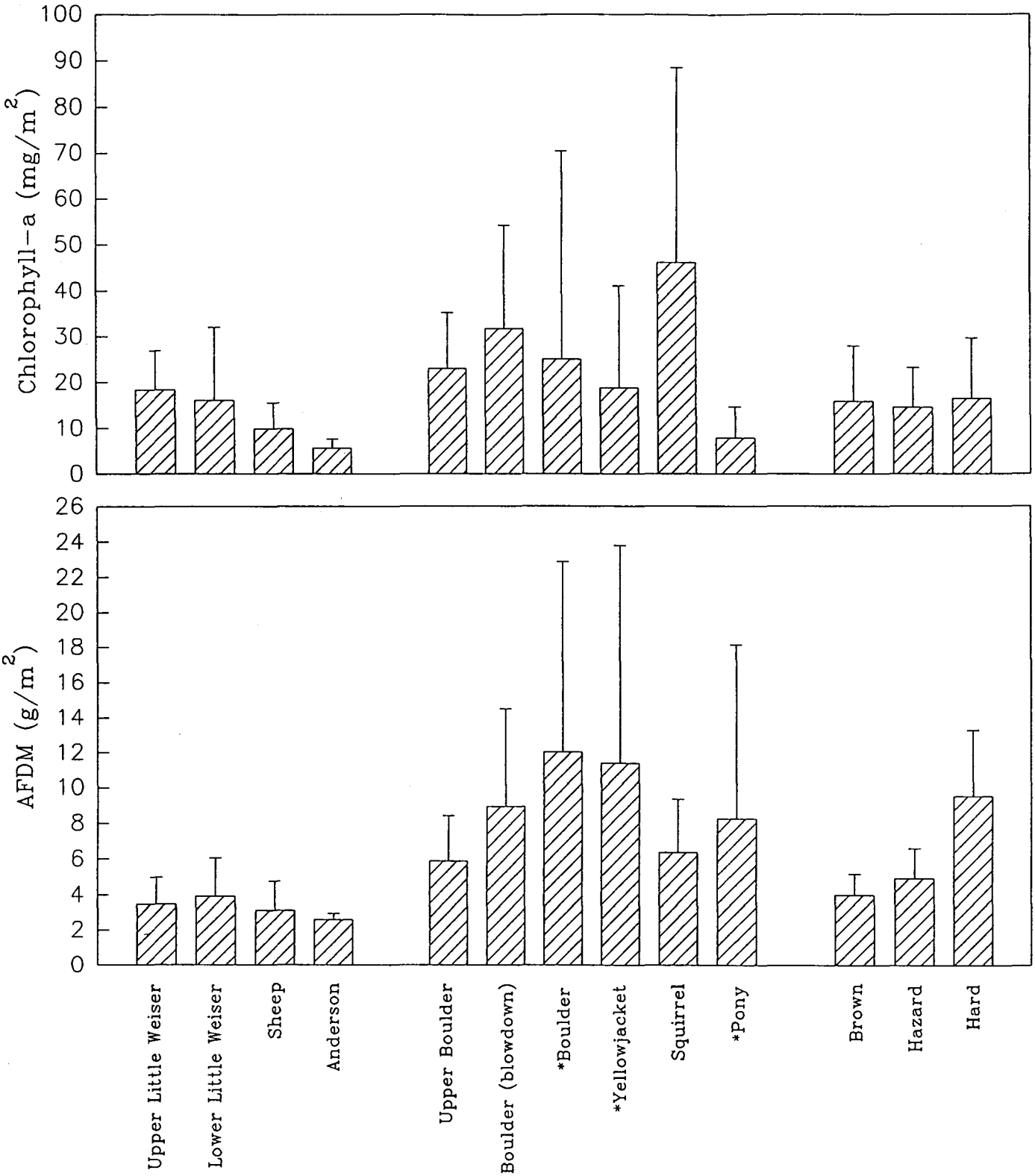

Figure 6. Periphyton chlorophyll a and ash-free dry mass (AFDM) values for the study streams. Error bars equal one standard deviation from the mean, n=5. * Indicates streams sampled in 1992, n=10.

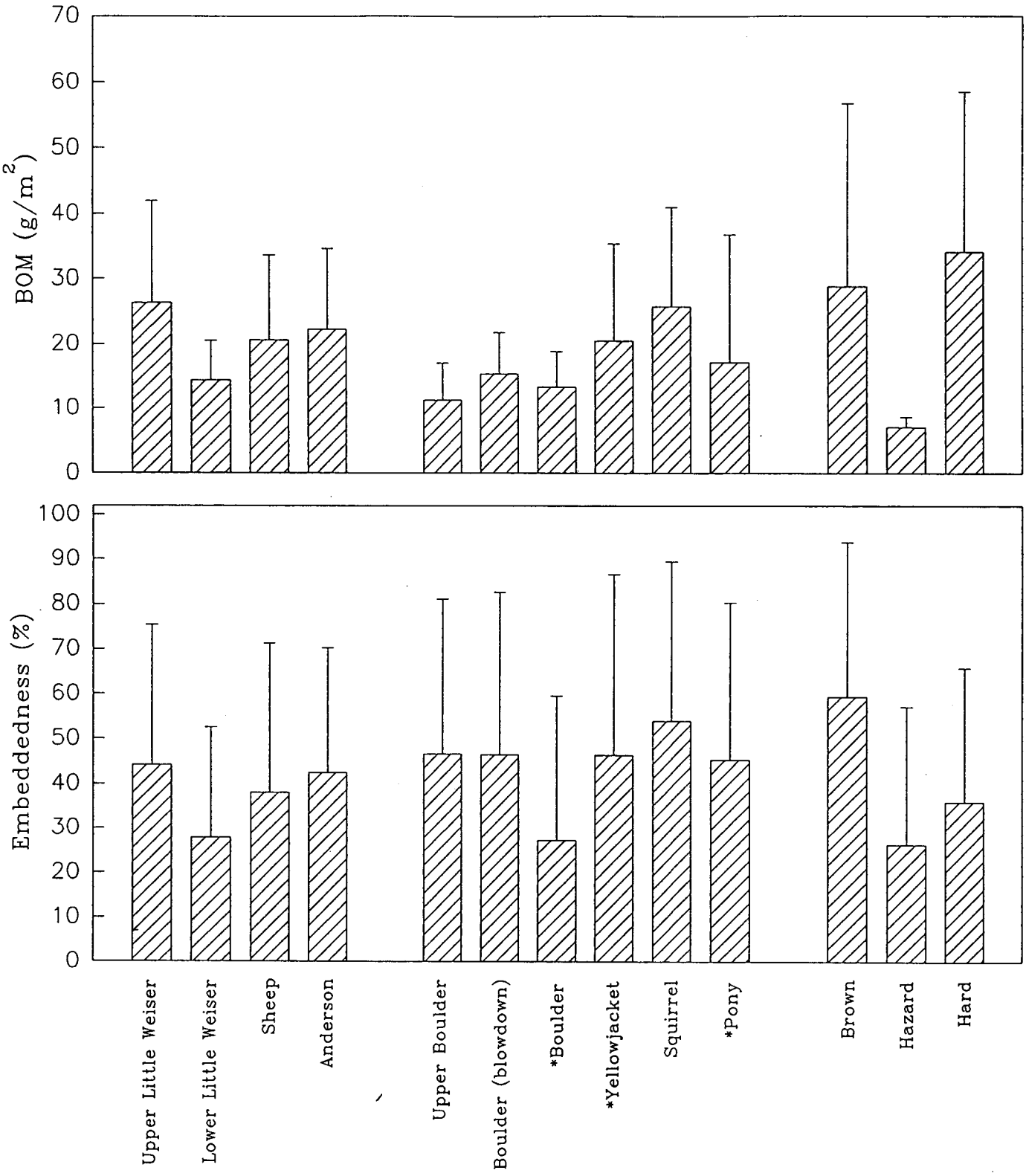

Figure 7. Benthic organic matter (BOM) and substrate embeddedness values for the study streams. Error bars equal one standard deviation from the mean, n=5.(*n=10) for BOM; n=100 for embeddedness.

not as strong when Boulder and Hazard Creek catchments were examined individually ($p=0.255$, $R^2=0.31$; $p=0.551$, $R^2=0.42$, respectively), possibly due to low sample sizes. However, in the Little Weiser River catchment the positive relationship between substrate embeddedness and BOM was quite strong ($p=0.017$, $R^2=0.97$) even with a sample size of only 4 sites (Figure 8). It appears that land-use practices in the Little Weiser River catchment in particular, and to a lesser extent all the streams sampled, have resulted in elevated sediment inputs (as reflected in the organic fraction) that have increased substrate embeddedness in the receiving streams.

Principal components analysis (PCA) was used to identify those streams which differed from the group as a whole (all catchments combined) and the variable(s) (biotic or abiotic) which caused the difference. Multiple discriminant analysis (MDA) was used to identify variables (biotic or abiotic) exhibiting the greatest difference among catchments. The positive (+) or negative (-) sign in front of each variable(s) on the axes titles indicates the direction of change in that variable as one moves along the axis (up the Y-axis, to the right on the X-axis).

In addition to the quantitative habitat variables discussed above, qualitative habitat measures also were utilized in the multivariate analyses (Table 5). The PCA for habitat characteristics showed measures of stream size (i.e., widths) to be important on the first axis (X-axis) and alkalinity, pool/riffle ratio, and channel capacity to be important on the second axis (Y-axis)(Figure 9). Yellowjacket Creek and the 1992 Boulder Creek site separated from the other sites as a result of much higher alkalinity values (see Table 3).

The MDA for habitat measures showed the streams of the Hazard Creek catchment differed from all other sites primarily in specific conductance and to a lesser extent in bank vegetation

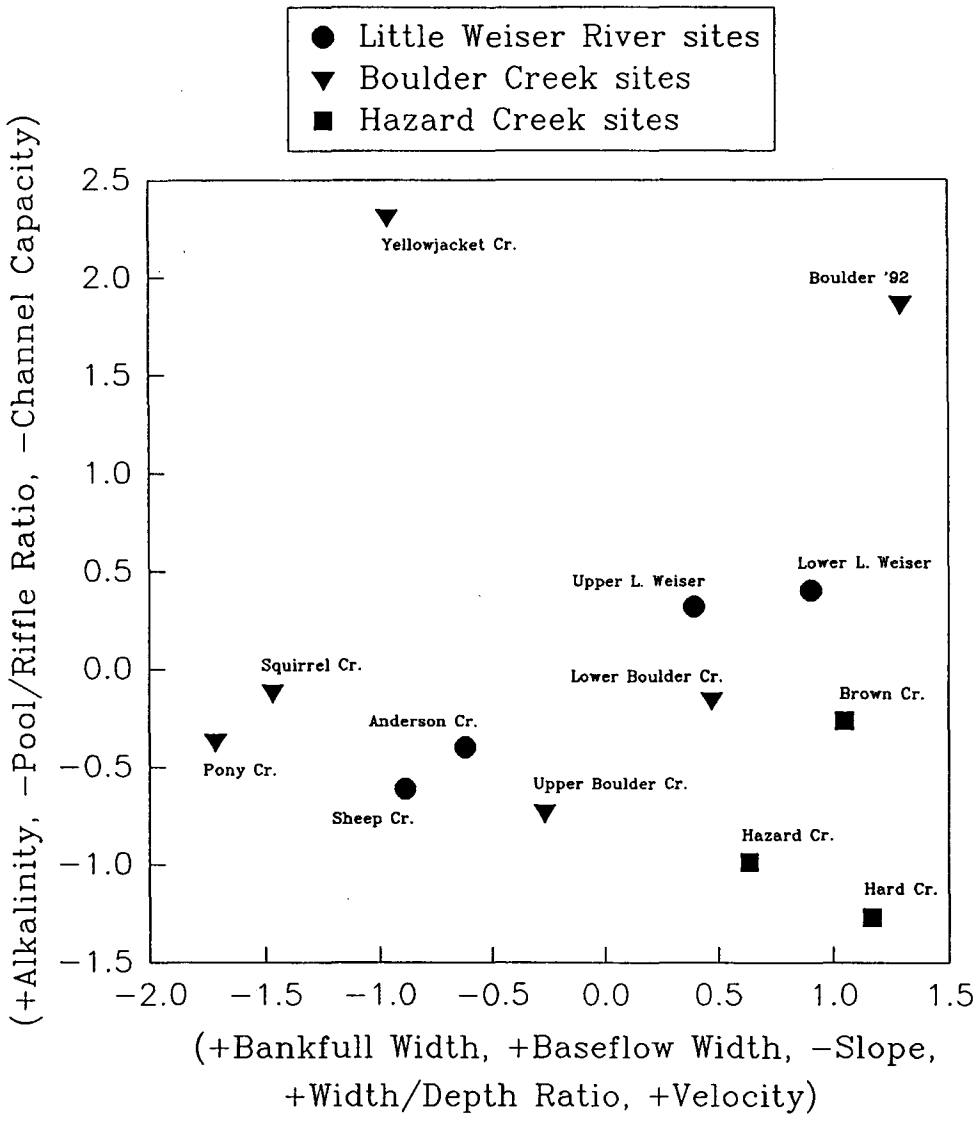

Figure 9. Scattergram of PCA results based on habitat measures. The first two axes explained 68% of the variation.

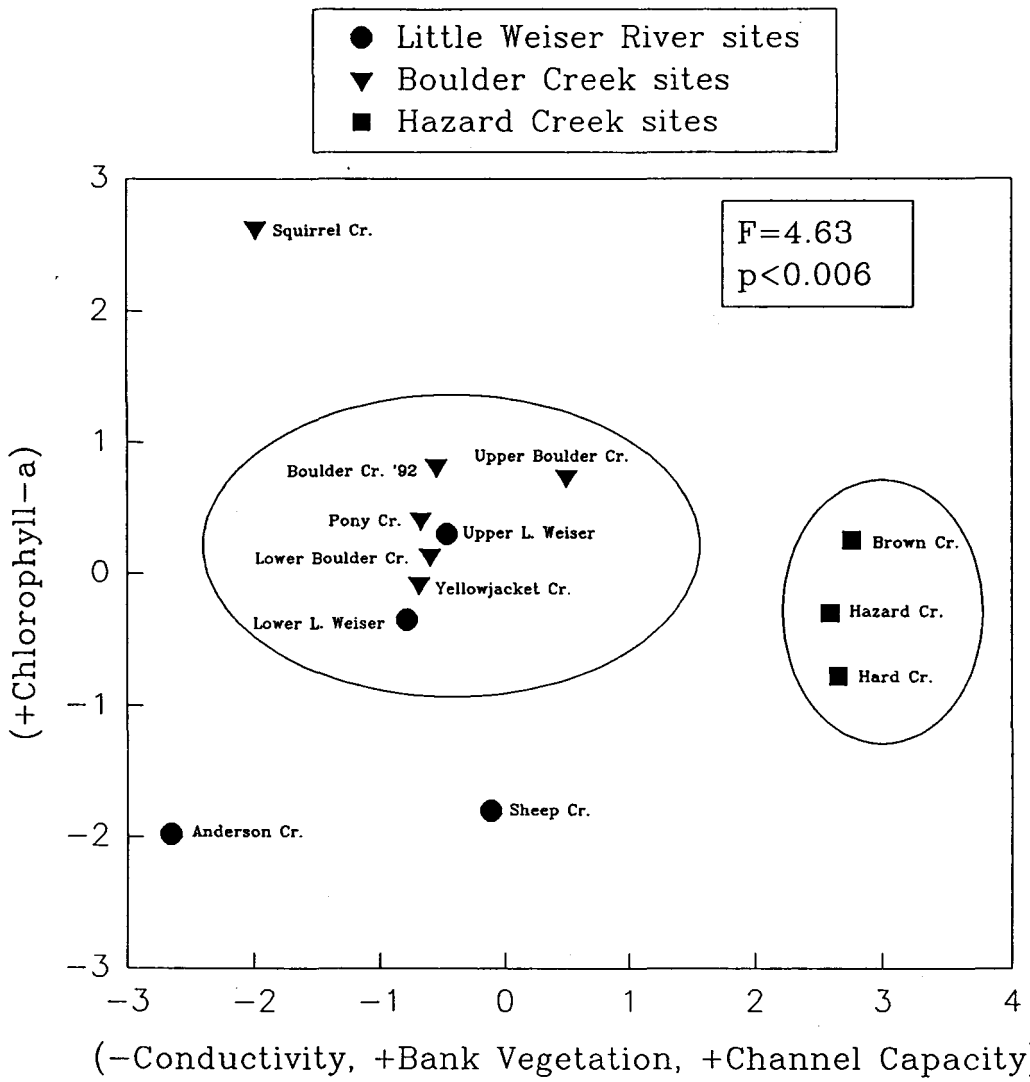

Figure 10. Scattergram based on MDA results from habitat measures. Circles fitted by eye to denote major groupings.

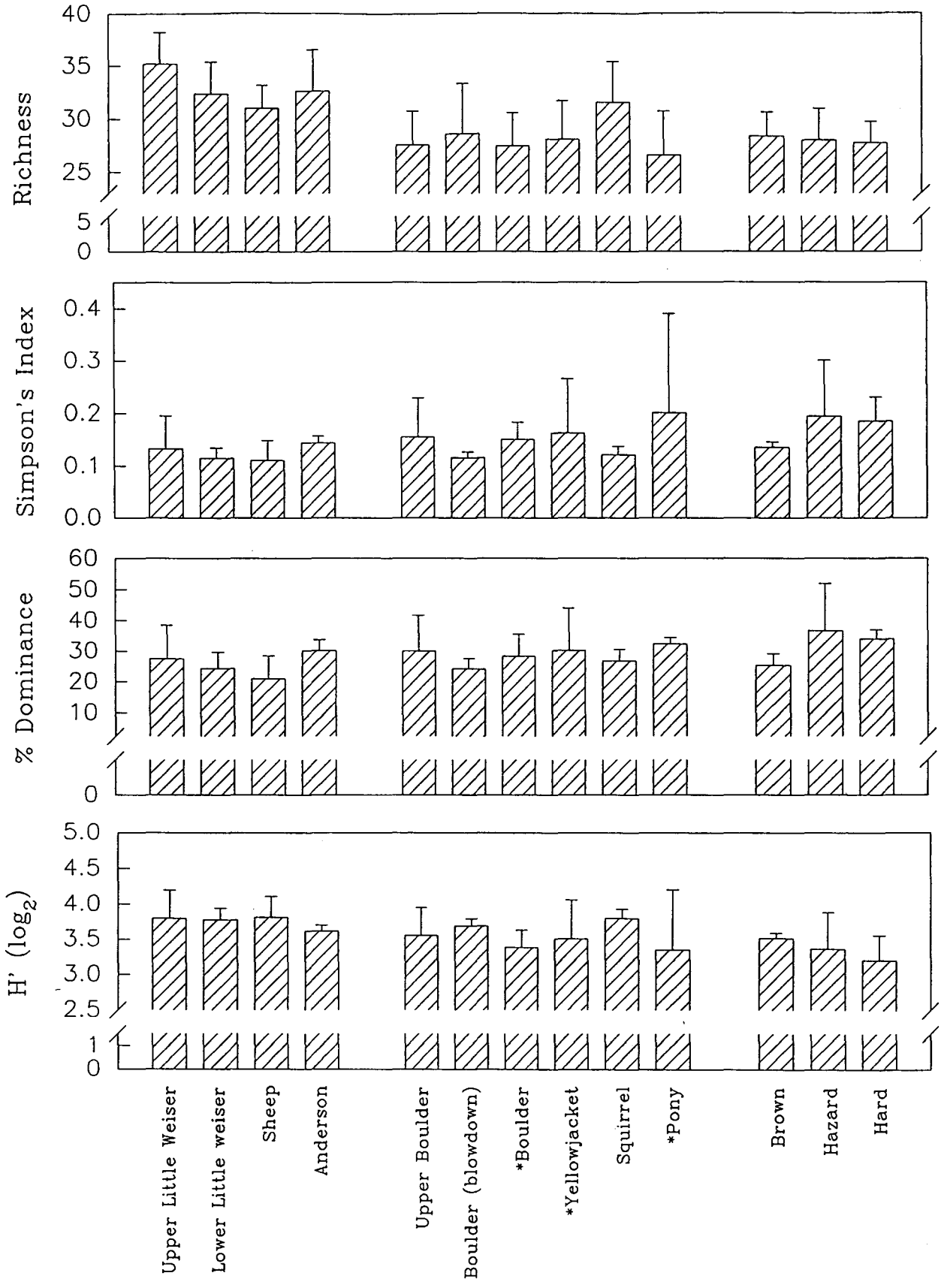

Figure 12. Richness, Simpson's Index, % Dominance, and diversity (H') among study streams. Error bars equal one standard deviation from the mean, n=5. * Indicates streams sampled in 1992, n=10.

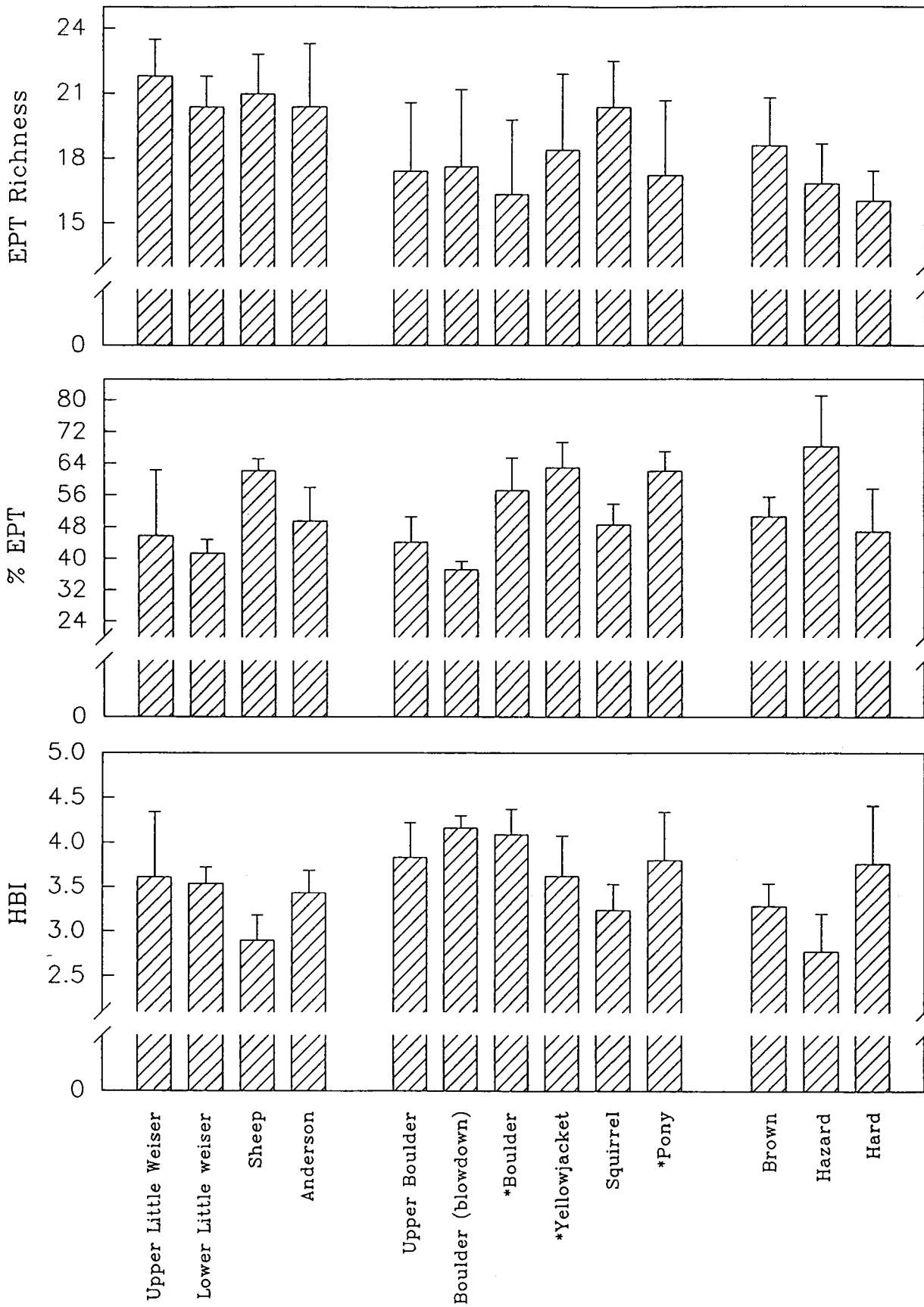

Figure 13. Richness and percentage of Ephemeropteran, Plecopteran, and Trichopteran (EPT) species and Hilsenhoff's Biotic Index (HBI) for the study streams. Error bars equal one standard deviation from the mean, n=5. * Indicates streams sampled in 1992, n=10.

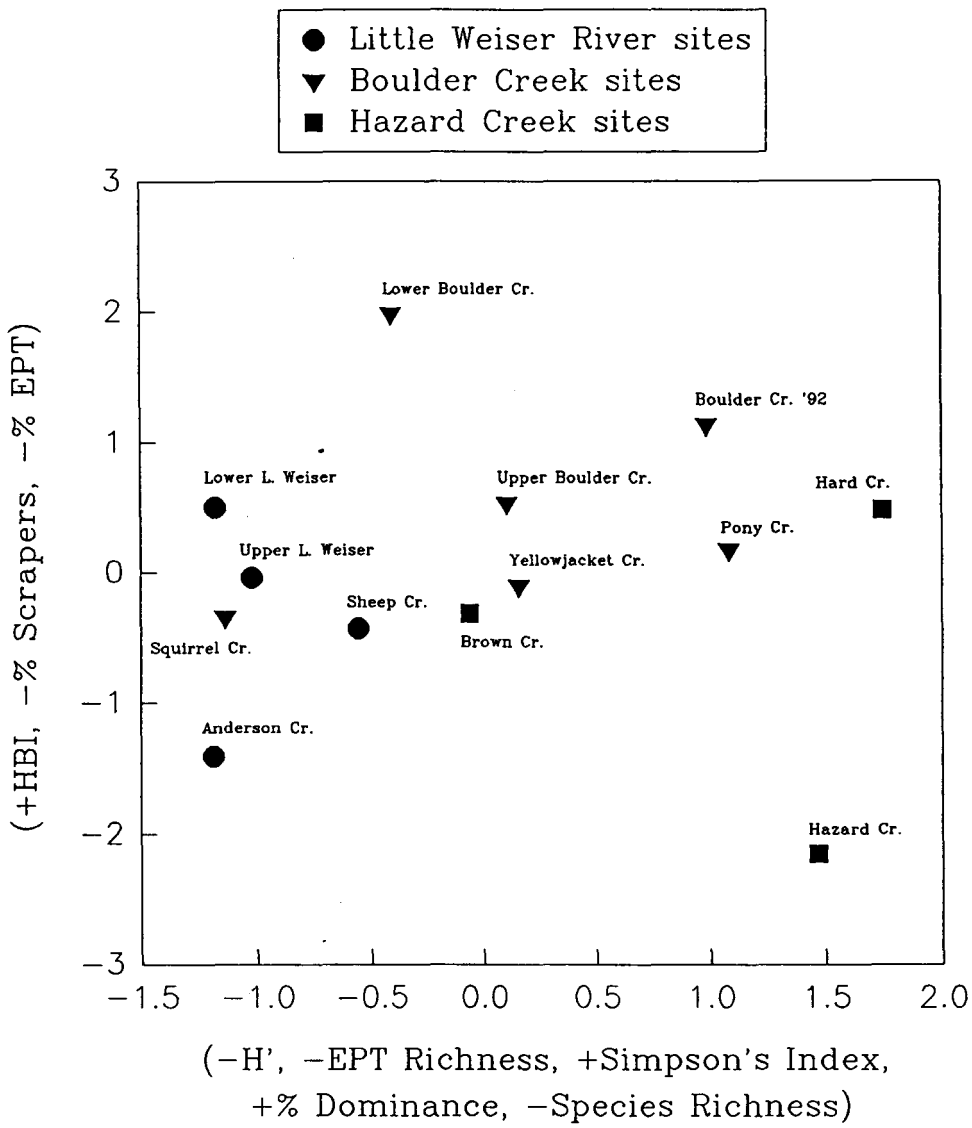

Figure 15. Scattergram of PCA results based on macroinvertebrate community measures. The first two axes explained 84% of the variation.

Table 6. Top ten taxa, by abundance, for streams in the Little Weiser River catchment.

	Density (No./m2)		Relative Abundance
	Mean	Std.	
Upper Little Weiser River			
Simulium sp.	2101	3967	14.9
Oligochaeta	1848	1504	14.2
Baetis bicaudatis	1494	724	10.2
Chironomidae	740	300	7.4
Hydracarina	671	157	7.0
Heterlimnius sp.	555	200	5.8
Capnia sp.	431	303	4.1
Rhithrogena robusta	354	228	3.9
Cinygmula sp.	350	70	3.3
Drunella doddsi	313	185	2.8
Lower Little Weiser River			
Oligochaeta	2155	776	18.8
Chironomidae	1130	358	14.4
Baetis bicaudatis	903	382	10.3
Rhithrogena robusta	738	275	9.3
Hydracarina	504	267	5.6
Optioservus sp.	442	142	4.8
Nematoda	422	260	4.7
Heterlimnius sp.	394	144	4.4
Serratella tibialis	300	98	3.5
Micrasema sp.	236	65	2.9
Sheep Creek			
Baetis bicaudatis	1126	273	18.8
Oligochaeta	939	391	14.0
Chironomidae	873	385	12.8
Rhithrogena robusta	622	110	8.1
Zapada sp.	354	284	4.7
Drunella doddsi	298	127	4.5
Cinygmula sp.	281	343	4.4
Capnia sp.	277	126	4.1
Rhyacophila vagrita	257	266	3.3
Hydracarina	206	97	3.2
Anderson Creek			
Baetis bicaudatis	1529	617	21.1
Oligochaeta	1516	681	20.1
Chironomidae	1424	970	17.1
Capnia sp.	287	116	3.5
Heterlimnius sp.	283	126	2.9
Zapada sp.	251	228	2.8
Rhyacophila vagrita	206	248	2.6
Pericoma sp.	199	129	2.4
Suwallia sp.	185	105	2.4
Drunella doddsi	184	94	2.1

Table 7 (cont.).

Yellowjacket Creek - 1992			
Oligochaeta	1071	876	28.2
Chironomidae	449	285	11.8
Turbellaria sp.	371	216	9.8
Cinygmula sp.	317	224	8.4
Epeorus sp.	219	303	5.8
Ephemerella infrequens	162	185	4.3
Nematoda	128	165	3.4
Micrasema sp.	118	159	3.1
Rhyacophila vagrita	99	67	2.6
Zapada columbiana	86	108	2.3
Squirrel Creek			
Chironomidae	1692	562	26.7
Oligochaeta	705	526	10.6
Yoroperla brevis	575	197	9.1
Neothremma sp.	457	209	7.9
Turbellaria	429	193	7.4
Baetis bicaudatis	262	92	4.5
Cinygmula sp.	247	64	2.7
Farula sp.	177	27	2.5
Serratella tibialis	161	99	2.4
Micrasema sp.	157	86	2.3
Pony Creek - 1992			
Oligochaeta	1151	1327	31.6
Chironomidae	712	558	19.5
Serratella tibialis	320	371	8.8
Cinygmula sp.	148	142	4.1
Turbellaria	138	169	3.8
Baetis bicaudatus	129	120	3.5
Yoroperla brevis	124	101	3.4
Rhyacophila vagrita	109	79	3.0
Epeorus sp.	97	69	2.7
Nematoda	78	143	2.1

taxa (Table 7). *Simulium* sp. was the most abundant taxon in the Upper Little Weiser site, yet did not appear in the top ten taxa of any other stream in that catchment (Table 6). *Baetis bicaudatis* was the most abundant species in all streams of the Hazard Creek catchment (Table 8). *Baetis bicaudatis*, *Simulium* sp., and the Chironomidae are generally considered disturbance adapted, and excessive abundances of these taxa may indicate impaired stream habitat conditions. Differences in the sampling dates for the streams (early versus late summer, see Table 1) may be partially responsible for observed differences in composition of the most abundant taxa among streams.

The PCA based on the ten most abundant macroinvertebrate taxa showed Hard and Hazard Creeks to separate out along the first axis, while Squirrel Creek differed along the second axis (Figure 17). Yellowjacket Creek and the lower Boulder Creek site (blowdown site) appeared slightly different from the other sites, primarily along the first axis.

The MDA based on most abundant taxa showed the Hazard Creek and Boulder Creek catchments to differ distinctly along the first axis, while streams in the Little Weiser River catchment differed along the second axis (Figure 18). The abundance of *Baetis bicaudatis* and *Drunella doddsi* distinguished the Hazard Creek catchment from sites in the Boulder Creek catchment. The Little Weiser River sites differed from the other catchments in density of *Capnia*, Oligochaeta, and *Rithrogena robusta*.

DISCUSSION

Chemically, streams of the Hazard Creek catchment appeared distinctly different from the other two catchments. These streams displayed specific conductance values ca. 50% lower than any site from the Boulder Creek or Little Weiser River catchments. Further, total alkalinity, and to a lesser extent

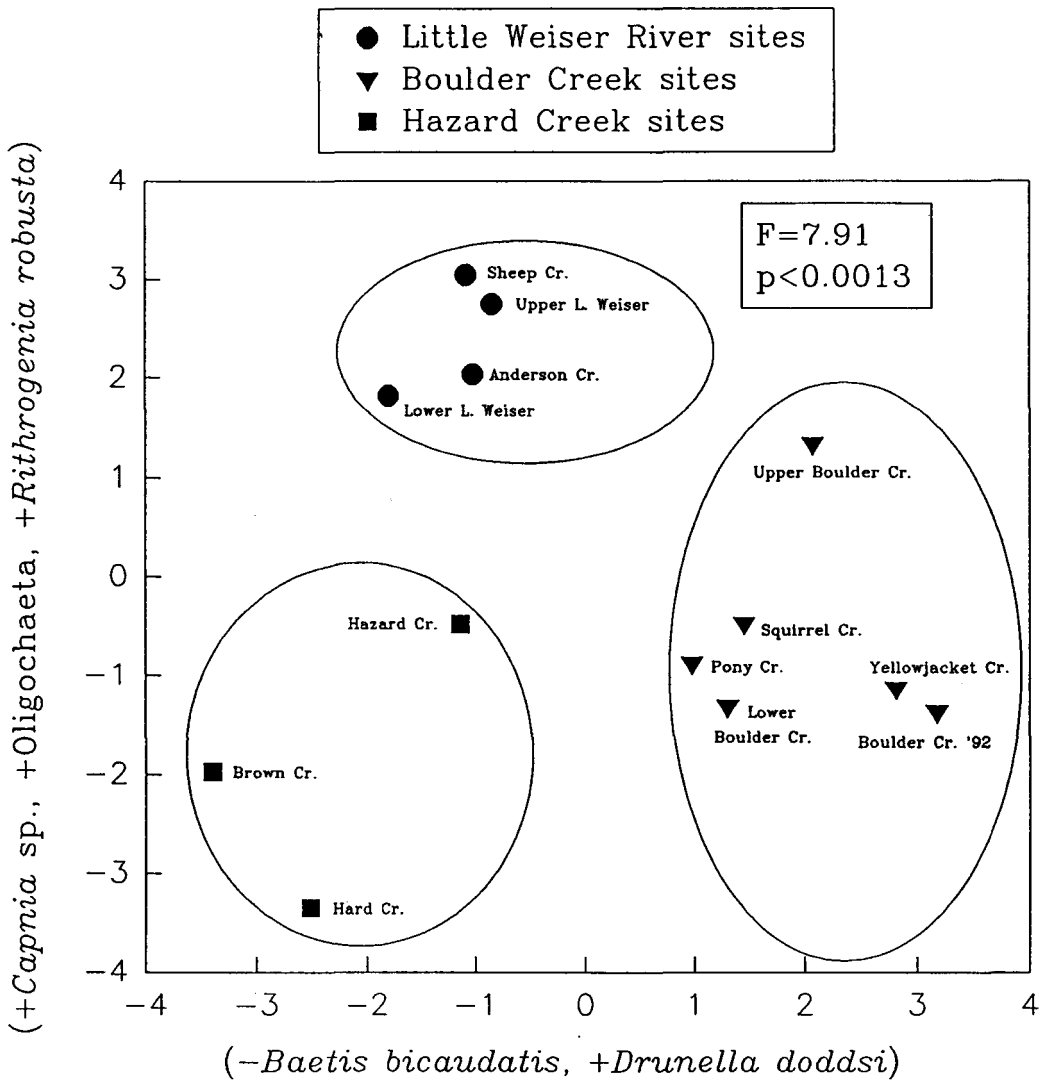

Figure 18. Scattergram based on MDA results from ten most abundant macroinvertebrate taxa. Circles fitted by eye to denote major groupings.

embeddedness of sites in the Boulder Creek catchment. Elevated chlorophyll-*a* and substrate embeddedness are both typical effects of livestock grazing within the riparian zone of a stream (see review in Platts 1991). However, Squirrel Creek did not show impaired benthic diversity nor an abundance of filter feeding macroinvertebrates (generally indicative of excessive sediment load). A possible explanation for this apparent discrepancy is that the steep gradient and "stair-step" nature of Squirrel Creek are mitigating the effects of livestock grazing.

In general, the present study, combined with data from 1992, showed streams in the Hazard Creek catchment to be distinctly different from either the Boulder Creek or Little Weiser River catchments. Future research in the Hazard Creek catchment should be designed to determine the effect of land-use practices in relation to reduced chemical richness (i.e., alkalinity and specific conductance). Further reconnaissance and comparison of the adjacent catchments of Pony and Squirrel Creeks seem warranted to better determine the reasons for the marked differences between the two systems. Sites in the Boulder Creek and Little Weiser River catchments appeared rather similar, although more detailed research, including reference sites from within the Little Weiser River catchment, would be required to demonstrate that the two systems are responding in the same manner to similar land-use practices.

LITERATURE CITED

American Public Health Association. 1989. Standard methods for the examination of water and wastewater. APHA, New York.

Bovee, K. D. and R. Milhous. 1978. Hydraulic simulation in instream flow studies: theory and techniques. Cooperative Instream Flow Service Group, Western Energy and Land Use Team, U.S. Fish and Wildlife Service, Fort Collins, Colorado.

Buchanan, T. J. and W. P. Somers. 1969. Discharge measurements of gaging stations. *In*: Techniques of Water Resources Investigations. Book 3, Chapter A8. U.S. Geol. Survey.

Egglishaw, H.J. and N.C. Morgan. 1965. A survey of the bottom fauna of streams in the Scottish Highlands, Part II. The relationship of the fauna to the chemical and geological conditions. Hydrobiologia 26:173-183.

Greeson, P. E., T. A. Ehlke, G. A. Irwin, B. W. Lium, and K. V. Slack (eds). 1977. Methods for collection and analysis of aquatic biological and microbiological samples. Techniques of Water-Resources Investigations. U.S. Geol. Surv. 322 p.

Lee, R. 1980. Forest hydrology. Columbia University Press, New York.

Leopold, L. B. 1970. An improved method for size distribution of stream bed gravel. Water Resources Research 6:1357-1366.

Lind, O. T. 1979. Handbook of common methods in limnology. 2nd edition. C. V. Mosby Co., St. Louis. 199 p.

Merritt, R. W. and K. W. Cummins (eds). 1984. An introduction to the aquatic insects. 2nd edition. Kendall/Hunt Publishing Co., Dubuque, Iowa 722p.

Minshall, G. W. and C. T. Robinson. 1993. Final report to the USFS Intermountain Station on stream ecology research performed during summer 1992. Final report to the Payette National Forest, 25 p.